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AN ADAPTIVE IMAGE CODING TECHNIQUE USING INTERPOLATIVE MIXED VQ *

Zhenya He Jihong Zhang Yiming Mao
Radio Engineering Dept.
Southeast University
Nanjing 210018, P.R.China

ABSTRACT

In this paper we developed a new adaptive image coding technique using interpolative mixed Vector Quantization (VQ) which mixes 2-D Discrete Cosine Transform (DCT) with VQ. A median filter is first used as eliminate fine noise while not smearing edges. After subsampled, the image is encoded by an adaptive mixed VQ coding scheme. At the receiver, we use a FIR Median Hybrid (FMH) filter to interpolate missing pixels after subsampling. Some simulation results are given. It is found that high-quality coded images were obtained at bit rate from about 0.25 to 0.5bpp.

I.Introduction

Transform Coding (TC) has been proved to be an efficient way for image compression. The most popular transform is the well-known DCT. A relatively new technique is VQ [1]. From the theoretical point of view, VQ provides the best performance among all block structured image coding schemes for a given block size and bit rate. In practice,however, to fully utilize the inter-pixel correlation of real world images large block sizes (hence, very large codebooks) are needed for the VQ. Since codebook size grows exponentially with the number of index bits, it is currently impractial to construct VQ codebooks requiring mor than 10 or 12 bits. Some attempts have been mad to circumvent complexity problem that apply TC i combination with VQ coding that overcome the sub optimalities of TC and combined the advantages of VC to increase the coding performance [2].

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In order to further reduce bit rate and the computational complexity, in this paper, we developed a new adaptive image coding technique using interpolation mixed VQ which mixes 2-D DCT with VQ . Ou adaptive coding scheme is shown in Fig.1.

II.Image Prefiltering And Decimation

The lowpass filters have found applications in image high compression, and many authors have analyzed the properties of these filters. They are used to obtain the lowpass image from the original image and also to protect against aliasing effects in subsampling step. Because linear lowpass filters tend to smear edges and eliminate relevant details, in our coding scheme, a median filter is used as prefilter to eliminate fine noise while not samearing edges [3-5]. The small fine detail is often noise or is so small and so fine that the eye cannot discern it. In either case, compression is usually better without this detail.

In our coding scheme, the median filter is defined as follows. Let $[X_{ij}]$ be the matrix representing a image. Then the result of the median filtering with an $m \times n$ (where $m, n =$ odd integers) window is an image

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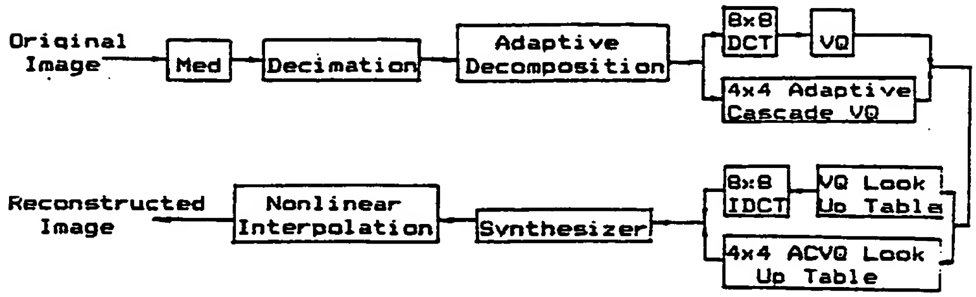


Figure 1: Block diagram of our coding scheme

$_{ij}$] where Y_{ij} is equal to the median of the gray levels of the picture elements lying in an $m \times n$ window centered at the picture elements X_{ij} in input image. When window is close to ender in the horizontal or vertical direction, m or n decreases by 2 at each filtering step. Since neighboring pixels in images are highly correlated, the image redundancy can easily be reduced by subsampling. Most parts of the information is still in the subsampled image.

III. Adaptive Mixed VQ

A quadtree algorithm is first used to partition the resulting image into blocks of size, 8×8 and 4×4. The blocksize is dynamically adjusted according to the local property of detail contents within each block [6]. Each 8×8 block is checked for detail contents using the following detail test:

$$T = \frac{1}{K}\sum_{i=1}^{K}(x(i) - u)^2 \qquad (1)$$

where K is the number of pixels in the block, $x(i)$ is the grey value of i_{th} pixel and u is the mean grey value of all the pixels in the block. The detail threshold value is predefined. If T does not exceed this threshold, this block is considered to be a "low detail" block. Otherwise, the block is considered as "high detail" and is split into four 4×4 subblocks.

The large blocks, 8×8, are coded by a DCT-VQ scheme. In this algorithm the transform coefficients of each blocks are grouped into vectors which are then individually coded using VQ. The grouping is done by requiring that all components of each vector have approximately the same perceptual importance. The subvectors are formed as Table 1, Coefficient $(0,0)$ represent the mean luminance value intra-block, Since the human visual system is highly sensitive to errors in this mean luminance, it is quantized separately at 8-bit accuracy. The bit allocation of each subvector is in a manner that described in [7].

Table 1

The bit allocation table of DCT-VQ

m	+	+	+	+	+	–	–
+	+	+	+	–	–	0	0
+	+	+	–	–	–	0	0
+	+	–	–	–	0	0	0
+	–	–	–	0	0	0	0
+	–	0	0	0	0	0	0
–	0	0	0	0	0	0	0
–	0	0	0	0	0	0	0

"m" (DC)—8bit, "+"(VQ1)—7bit

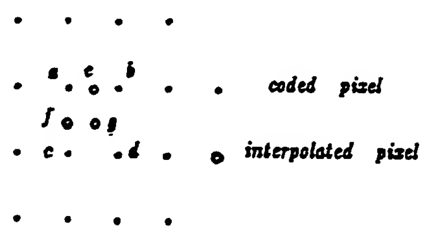
"-" (VQ2)—6bit, "0"—0bit

The high detail 4×4 blocks are encoded using space domain VQ. In order to reduce the computational

complexity and coding distortion, an adaptive muti-stage VQ technique is used [7]. The codebooks were designed using the well-known LBG algorithm [8].

IV. Nonlinear Interpolation

The FMH filters have been successfully applied to image processing and they are shown to retain edges and attenuate noise very well [9]. The FMH filters are also used to interpolate missing pixels after sub-sampling [5]. Edges are preserved and shade regions are further smoothed by FIR substructure. Nonlinear interpolator is shown in Fig.2.



$$e = \frac{(a+b)}{2} \tag{2}$$

$$f = \frac{(a+c)}{2} \tag{3}$$

$$g = MED(a,b,c,d,yfir) \tag{4}$$

$$yfir = \frac{(a+b+c+d)}{4} \tag{5}$$

Figure 2: Nonlinear Interpolators

V. Simulation Results

This adaptive coding system has been simulated on a AST 386 computer. Several images that were not part of the training set were coded by this system. Shown in Fig.3 is the reconstructed image by using the above scheme for "Lena" image. For comparision purpose, the original image is also shown. The input image is 8 bits per pixel, *i.e.*, a range of [0,255], and its size is 256×256. After prefiltered by median filter of size 5×5, the image is reduced by subsampling in a $2:1$ ratio in both the horizontal and vertical direction.

The subsampled image is first divided into blocks of size 8×8 and 4×4. The detail threshold value has been empirically defined to be 150 . The number of blocks of size 8×8 and 4×4 are 96,640 respectively. Then the large blocks are coded by a DCT-VQ system. As can be seen from Table 1, subvectors denoted by "+" and "-" are vector-quantized using codebooks with 128 and 64 codevectors respectively. The small blocks are coded by an adaptive multi-stage VQ. Table 2 gives the coding performance and the number of stages used in multi-stage VQ. The signal-to-noise ratio SNR is defined as

$$SNR = 10log\frac{255^2}{MSE}(dB)$$

where MSE stands for the Mean Square Error. Table 2 shows that the performance fo our coder is better than the performance obtained in [5].

TABLE 2

Performance Comparision

	SNR	*Bit/Pel*
IAVQ [5]	*28.66*	*0.250*
stage2	*28.42*	*0.228*
stage3	*28.71*	*0.244*

VI. Conclusions

In this paper we have described an adaptive image coding scheme based on combining median prefiltering, decimation, adaptive mixed VQ, and nonlinear interpolation. The algorithm yields encoding output of good quality at o.244bpp with relatively simple vector coder structure.

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(a)

(b)

Figure 3: (a) Original, and (b) coded at 0.244